From Chart Tracking to Workflow Management

Padmini Srinivasan
Gerard Vignes
Computer Science Department
(318) 231-5215
ps@cacs.usl.edu

Carol Venable
Anita Hazelwood
Toni Cade
Health Information Management
(318) 231-6629
cav0811@ucs.usl.edu

University of Southwestern Louisiana
Lafayette, LA 70504

Abstract

The current interest in system-wide integration appears to be based on the assumption that an organization, by digitizing information and accepting a common standard for the exchange of such information, will improve the accessibility of this information and automatically experience benefits resulting from its more productive use. We do not dispute this reasoning, but assert that an organization's capacity for effective change is proportional to the understanding of the current structure among its personnel. Our workflow manager is based on the use of a *Parameterized Petri Net* (PPN) model which can be configured to represent an arbitrarily detailed picture of an organization. The PPN model can be animated to observe the model organization in action, and the results of the animation analyzed. This simulation is a dynamic ongoing process which changes with the system and allows members of the organization to pose "what if" questions as a means of exploring opportunities for change.

We present, the "workflow management system" as the natural successor to the tracking program, incorporating modeling, scheduling, reactive planning, performance evaluation, and simulation. This workflow management system is more than adequate for meeting the needs of a paper chart tracking system, and, as the patient record is computerized, will serve as a planning and evaluation tool in converting the paper-based health information system into a computer-based system.

1 INTRODUCTION

Chart tracking, a basic function of the medical record department, is a legacy of the paper-based patient record, or *chart*. Although the task may be regarded as trivial, the benefits are by no means unimportant. In spite of the fact that most hospitals do tracking, charts occasionally disappear. Chart tracking programs exist which automate tracking tasks and allow the program's *operator* to keep tabs on active charts.

We present, as the natural successor to the tracking program, a "workflow management system" which incorporates modeling, scheduling, reactive planning, performance evaluation, and simulation in a package . This workflow management system is more than adequate for meeting the needs of a paper chart tracking system, and, as the patient record is computerized, will serve as a planning and evaluation tool in converting the paper-based health information system into a computer-based system.

The current interest in system-wide integration seems to be based on the assumption that an organization, by accepting a standard for the exchange of information, will improve the accessibility of this information and experience benefits resulting from its more productive use. We do not dispute this reasoning, but instead the assert that a much greater benefit can be realized by focusing not on integration, but on the task of developing a realistic picture of the how the organization actually functions—not the obligatory company hierarchy diagram, but a mosaic of the interplay between technical and human resources within the organization.

For integration is change, and not change of some abstract, anonymous work process, but change of the way people work with one another, and the attitude with which they judge the costs and benefits of this cooperation. If enough people in an organization are convinced that change is not going to profit their own work, then they will either rebel against the policy, or, far worse, quietly appear to accept it but simply ignore it. It has been said that careless application of technology allows people to make more mistakes faster. As a corollary to this, we offer that enforcement of policies or protocols designed to promote integration will encourage *everyone* to make the *same* mistakes consistently, without hope of improvement except through revolution against the standards.

An organization's capacity for coping with change is proportional to the understanding of the current structure among its personnel. Organizations often embody years of evolution and accumulated tacit knowledge that is never made explicit and yet is vital. Modeling is an aid in the understanding of complex systems and problems. Modeling techniques can help to overcome human cognitive limitations

The research described in this paper is the result of work that was funded by LEQSF Grant Number 058-B.

and help with the management of change. Models of an organization serve to make tacit knowledge explicit, representing processes *and* people, viewed from various vantage points and related to one other in ways not restricted by the need to preserve a hierarchical structure.

Our workflow manager is based on the use of a PPN model which can be configured to represent an arbitrarily detailed picture of an organization. This model can be animated to observe the model organization in action, and the results of the animation analyzed—with far less time and effort than would be necessary for a similar study of the actual organization. This is not just a simulation which might be conducted once a year as an adjunct to the "time and motion" study. It is, rather, a dynamic ongoing process which changes with the system and allow members of the organization to pose "what if" questions as a means of exploring opportunities for change. It also offers the opportunity to evaluate the consequences of those changes by implementing them on a model of the actual system..

Section two of this paper describes an ordinary chart tracking program, and gives a listing of reports typically produced. Section three presents the *software architecture* for the workflow manager, with a breakdown of the functionality of its components. Section four presents the workflow model of a simplified health information system, and section five concludes the paper.

2 THE TRADITIONAL CHART TRACKING PROGRAM

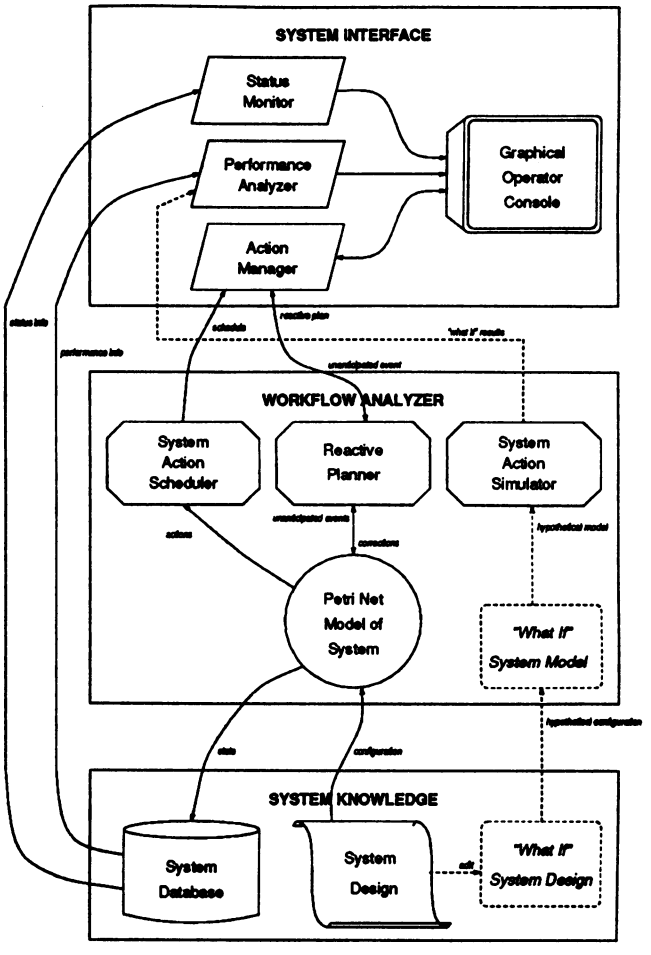
The traditional chart tracking program is essentially an online card index, holding the current status of each chart entered into the system. It may or may not provide enhanced chart lookup and report generation features, but either way it is a relatively unintelligent aid to the human operator. As new status information about the completion of the chart is entered, the previous information may be overwritten, or perhaps saved as a log of *transactions*, i.e., changes made to the status of the chart as new information becomes available.

Aside from offering quick access to the status of a chart and a convenient report on the system's progress, there is no automated assistance to the human operator. No mechanism is provided to detect inconsistencies in the status of a chart, so when important events are not recorded—or are recorded incorrectly—the system is not aware of the error, and it is up to the operator to discover the problem and piece together the puzzle of what actually happened. Any intelligent, useful application of the information contained within the memory of the tracking program comes entirely from the human operator. As the number of charts in the system increases, the operator's ability to extract useful information and manage the system by "brute force" deteriorates.

The list below is compiled from various "wish lists," both published and from interviews, of desirable chart tracking reports. These reports serve as the basis for determining the functionality expected of an intelligent chart tracking system.

1. Medical Records Order List
2. Unavailable Medical Records List
3. Post-Dated Requests Summary

Figure 1: Workflow Management Software Architecture



4. Down-Time Location List
5. Borrowers in Possession for Greater than 30 Days
6. Medical Record Department Activity
7. Restricted Medical Records Report
8. Delinquent Medical Records Report
9. Archived Medical Record Locations
10. Incomplete/Delinquent Letter Generation

3 SOFTWARE ARCHITECTURE OF A WORKFLOW MANAGEMENT SYSTEM

A diagram of the proposed workflow management system is shown in figure 1. The components of this architecture can be divided into three segments, system interface, workflow analyzer, and system knowledge. The *System Interface* allows the user to monitor the status of patient records, analyze the performance of the overall system, and manage the actions of the system. The *Workflow Analyzer* schedules normal system actions, drafts reaction plans to unanticipated events, and allows the user to pose "what if" situations and analyze the results. A Parameterized Petri Net

(PPN) [1] is used to animate and study a model of the system. Petri Net technology is used in knowledge representation and system modeling for simulations and dynamic management. The *System Knowledge* segment consists of a system database to store the status of all records, the system design which specifies the configuration of the model used to control the workflow analyzer, and alternative versions of the system design which the user has edited to pose "what if" questions.

Graphical Operator Console — displays for the operator the status of individual records, suggested and adopted schedules, suggested and adopted reaction plans, and metrics on system performance.

Status Monitor — determines and summarizes the status of individual records and the system.

Performance Analyzer — offers the user an assortment of pre-programmed reports as well as the capability to compose "ad hoc" status queries.

Action Manager — provides an interface for operator and system specified actions and alerts.

System Action Scheduler — uses transition rules and the status of records in the system, along with the system invariants, to construct a possible set of actions for managing medical records.

Reactive Planner — uses the same transition rules and status of records as the scheduler, but instead of being asked to schedule events under system invariants, it attempts to "force fit" an unanticipated event (e.g., unanticipated outcome, manual override of normal priorities ...) in the quickest and least obtrusive method available to it. The unscheduled event planner is the 911 service for the tracking system.

System Action Simulator — accepts a starting state for a hypothetical tracking system and proposes a schedule of actions for managing records. It animates this hypothetical system based on the conditions specified, and submits its results for performance evaluation.

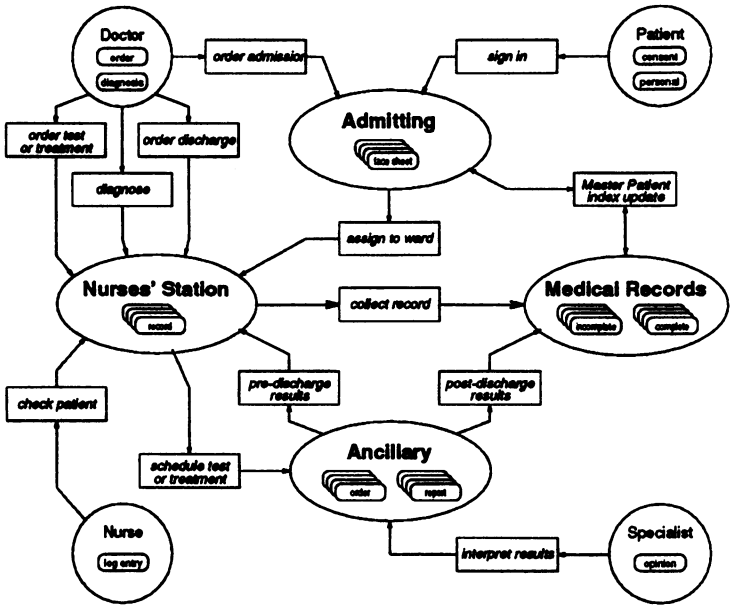
Petri Net Model of System — represents the knowledge regarding the state and dynamic features of the information system, using multiple views to manage complexity in the representation. Section 4, an example workflow model, elaborates on this

System Database — stores the status of each record, and other related and necessary information.

System Design — provides the system with a set of inputs determining the PPN model for a particular system. These inputs include possible system actions along with their necessary and sufficient conditions.

"What If" System Design — is an operator-modified version of the system, used for representing and analyzing proposed changes to the actual system.

Figure 2: Workflow Model of a Health Information System



"What If" System Model — is the PPN model produced in response to the operator's "what if" design. It animates the model and makes results from the animation available for analysis.

4 WORKFLOW MODEL OF A SIMPLIFIED HEALTH INFORMATION SYSTEM

Figure 2 contains a simiplified view of the PPN for a hospital infomtion flow or chart movement. The oval and circular nodes are places, and represent department locations or personnel involved in the action. The rectangles are "transitions", and represent actions that can be applied to objects (records, information items) int the input "place" (from which an arc is directed to the transition) resulting in the objects being in the output "place" (to which an arc is directed from the transition) of the transition.

The theoretical underpinnings of this representation technique are discussed in [1]. Support of multiple views through parameterization is also discussed. Available PPN analysis methods allow the determination of useful properties of dynamic systems.

The medical records are "tokens" that move between places and are altered via transitions. The existence of a medical record in a place is necessary for transitions having that place as the input place to "fire" or operate upon that medical record. It is possible to associate time delays with a place or transition. Animations allow one to observe objects moving through transitions on the screen. An iconic and more intuitive interface is under development.

Simulating the system is equivalent to having the PPN model "run" (transitions fire) on an artificial set of medical records and events. The workflow analyzer can simultaneously "track" the status of the medical records by the state of the net, or its markings, stored in a database. Business

process improvement planning is tantamount to altering the PPN model and carrying out a simulation-based performance analysis of the proposed system. The PPN representation of the system is the core of the workflow management software architecture. Prototype models for two healthcare institutions have been developed and demonstrated.

5 CONCLUSION

In this paper is presented a knowledge representation methodology and an associated software architecture that has been extensively and effectively used in manufacturing and command, control and communications applications. Considering the health information system as an information assembly and retrieval process and given the objective of cost reduction and rationalization in re-engineering this process, we propose this model based methodology for use in the healthcare institutions. Chart tracking is identified as an existing function in health information management that can be directly extended for performance evaluation. Existing chart tracking systems are not model-based; they are log-based. They incorporate database capabilities but not simulation, planning and predictive capabilities. The workflow manager discussed accomplishes model-based chart tracking and provides the fundamental modeling and simulation capabilities neded for evaluation of strategies in business process re-engineering/automation.

6 REFERENCES

[1] "Parameterized Petri Nets and Their Application to Planning and Coordination in Intelligent Systems," P. Srinivasan, D. Gracanin and K. Valavanis, *IEEE Transactions on Systems, Man and Cybernetics*, Vol. 23, No. 10, Oct. 1993

[2] "Health Care Computing in the 1990s," K. C. Cerny, *Thinkwork*.

[3] "Work Is a Closed-Loop Process," Peter J. Denning, *American Scientist*, Vol. 80, July-August 1992.

[4] "Infomation Flow Models for Two Healthcare Institutions" P. Srinivasan, V. Yekkirala, and K. Dahlgreen, *USL Technical Report 15-94*.